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Transactions of the Royal Society of Gottingen, from 1828 *to* 1831. Vol. VII. Presented by the Society.

Proceedings of the American Philosophical Society, to July, 1840. (No. 12.) Presented by the Society.

Directions for using Philosophical Apparatus. By E. M. Clarke, Esq. Presented by the Author.

Manuscript Notices relating to the Cathedral of St. Patrick, Armagh. By John Davidson, Esq., M.R.I.A. Presented by the Author.

Ordnance Survey of the King's County. In 49 Sheets, including Title and Index. Also,

Ordnance Survey of Carlow. In 28 Sheets, including Title and Index. Presented by His Excellency the Lord Lieutenant.

November 30, (Stated Meeting.)

SIR WM. R. HAMILTON, LL.D., President, in the Chair.

Dr. Kane read a Paper "On the Production of Audible Sounds," of which the following is an abstract.

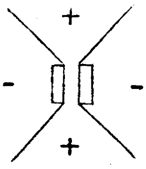
The sensation of sound is produced upon the ear by the tympanum being thrown into vibratory motion, isochronous with the vibrations transmitted from the sounding body.

Any body which vibrates as a single mass gives origin at the same moment to two waves, whose motions are in opposite directions, and of which one is rarefied and the other condensed.

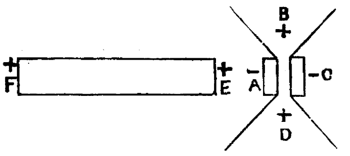
If these two arrive at the tympanum at the same moment and with equal power, perfect neutralization should result, and no sound be heard: hence, where a vibratory body produces upon the ear the sensation of sound, it arises from one wave of the two being either totally intercepted or, at least, diminished in force, and the loudness of the sound is proportional to the difference of the intensity of the two waves when they affect the ear.

All instruments for increasing sound, and producing resonance, act upon this principle.

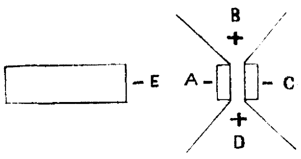
The following facts will illustrate these principles in detail. A tuning fork is a centre of four waves, two + and two —, but unless it be very close to the ear, no sound is heard from it; because the centre of all the four waves being very close, all act on the ear with equal force, and the difference is 0, (approximatively.)



Now, if an open tube, of the same length as a one-phase wave from the fork, be approached to one centre, as A, in the adjoining figure, the air in it commences to vibrate in unison with the fork, from being set in motion by the first wave which passes into it: the vibration of the tube is, however, a phase behind that of the fork, and hence, when a — wave passes from the centre A, it meets a + wave from the end of the tube E, and both are destroyed. The — centre, C, destroys also a + centre, as D, and there remain only the centres of + waves, B from the fork, and F from the tube, and these acting in concert on the tympanum produce the sound that we hear.

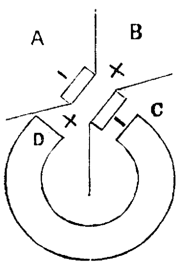


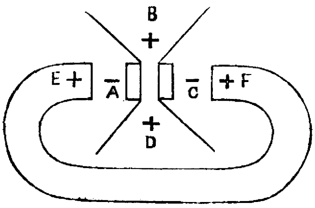
If the tube be closed, and of only one-half the length, the + wave, which emanates from the centre A, passes in, and being reflected from the bottom, issues again at the moment when the next — wave from A is about to enter; E and A then destroy each other, and C and D also interfering, there results only the + wave B, which acts unimpeded on

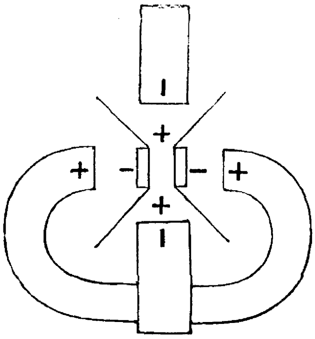


the ear. The sound of an open tube is, therefore, *ceteris paribus*, much stronger than that of a closed tube, as there are two waves in place of one.

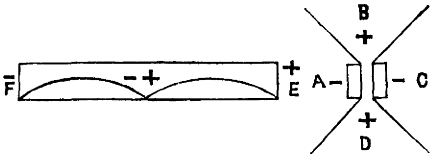
That the office of closed tubes, when resonant, is to destroy a portion of the sound of the original vibrating body, and of the open tubes to afford, in addition to that, a new centre of a wave of the same phase as that which remains, may be exhibited in many ways. Thus, Mr. Adams shewed long since, that when two closed tubes are placed at right angles to each other, they interfere when made to speak to a tuning fork, and for this effect no explanation has hitherto been given. But it is evident that the tubes being at right angles to each other, the waves destroyed are in opposite phases, and those which remain are in opposite phases also, so that the effect is the same as if no tubes were present at all. The same effect may be produced by a single tube, bent so that its apertures may be at right angles to each other; the — and + waves, D and C, meeting in the tube, produce neutralization, and the waves A and B, also + and —, which remain, interfere also, and hence no sound results. In an open tube bent into a circle, as in the figure, the two waves destroyed (A C) are of the same phase, and also those which remain, (B D,) and hence, such a tube sounds with nearly double the power of an ordinary open tube. That it is the sound of the waves which do not go into the tube, and not that of the waves in the tube, we hear, may be shewn by applying two closed tubes, as in the next figure. When the two — waves are absorbed







by the circular open tube, each closed tube absorbes a + wave, and hence, notwithstanding that there is so much vibrating material, no sound is heard. But if the tubes A and B were open, then the vibrating centres should have been simply transferred to their farther extremities, and the tubes would emit sound as the fork had done without them in the preceding figure.



If the open tube be double the length of a phase, then the neutralization occurs as in the figure, the residual waves being B and F, in opposite phases; but as their centres are separated so far, they interfere only in hyperboloidal planes, which are not detected unless when carefully sought for, but have been noticed to exist by Savart, although he did not suspect their cause.

All these principles have received very full verification from an instrument constructed for the purpose, and termed a *Chorizophone*. It consists of a square glass plate, which is placed above a set of closed tubes of such size, that when the plate vibrates in four pieces, with diagonal nodal lines, the length of each tube is half the length of the phase of the wave produced, and their form is triangular, of the magnitude of one of the four vibrating portions of the plate; when one of these tubes is presented to the plate, and this brought to vibrate by a violin bow applied to the centre of one of the sides, the tube resounds, and more loudly in proportion as the plate is brought nearer to its orifice. Now here the entire wave from the plate is caught by the tube, and the more perfectly its escape into the air is prevented, the louder is the sound produced, the sound must arise therefore from the waves which do not pass into the tube. Any one or more waves may thus be absorbed by the closed tubes, and a range of loudness of sound produced from the same plate with one or more of the four tubes, according as they are disposed as follows :

The vibrating plate gives eight waves, four above and four below, 4 being + and 4 minus.

With one tube, one wave is absorbed, and 3 + and 3 — destroying each other, a wave remains opposite in phase to that which is absorbed, and produces an audible sound.

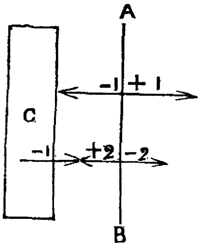
With two tubes, the waves absorbed may be either of opposite or of the same phases. If opposite, then, the remaining waves are 3 + and 3 —, and no sound is produced; but if the waves absorbed be of the same phase as +, then there remains 4 — and 2 +, and hence the ear is doubly affected by 2 —. The two tubes may be either both above or both below, or one above and one below the plate.

With three tubes, the absorbed waves may be either all of the same phase, or two of one and one of the other. In the first instance, 3 + being absorbed, there remains 4 — and 1 —, and the ear receives the impulse of 3 —. In the other case 2 + and 1 — being absorbed, there remains 2 + and 3 — and the impulse on the ear is only 1 —. The position of the tubes may vary in this as in the former case.

With four tubes, the absorption may be either all of the same phase, or 2 + and 2 — . In the former case, the remaining waves will be either 4 + or 4 —, in which case the greatest sound the plate can produce is heard, or else there remain 2 + and 2 —, in which case the plate gives no sound. These results prove fully that it is the residual sound that is heard, and not that which passes into the tube.

A vibrating plate gives some sound always, even without the tubes, for since there are at least eight waves, some one will always be more favourably disposed for acting on the ear than another, this difference will increase with the number of waves; and hence, the independent sound of a plate increases in proportion as the vibrating portions into which it divides, become more numerous.

A string vibrating in free space, produces little or no sound; but if it be strung over, or in connexion with, an elastic board or box, a great resonance is produced. This arises from two sources; first, the string when by itself is the centre of two waves excessively close, and the action of which is therefore interfering. But if the string AB, vibrate near a plane surface C, the wave — 1, which passes towards it is reflected back, and meeting the wave + 2, which follows, it neutralizes it partly, and enables the wave — 2, to reach the ear without diminution. It is probable, however, that the great portion of the sound arises from the board or plate itself vibrating in parts, or as a whole. If in parts, these parts are variously situated, as regards the ear, and hence produce an effect upon it. Or if, as a whole, the plate C is so broad, or bounded, if a box, that one wave is lost by internal reflexion, and only the wave emanating from the outer surface can arrive at the ear.



When a tuning fork is placed on a table, one wave is lost by internal transmission and reflexions, whilst that directed from the outer surface reaches to the ear.

In the case of reed instruments, the reed produces two waves, which, if it vibrated freely, should neutralize each other on the ear; but in practice whilst an open passage is allowed to one by the mouth-piece, the other wave is lost within the cavities of the lips and mouth. In mouth-piece instruments, as bugles and trumpets, the cavity of the mouth serves also for the absorption of the one wave, leaving the other free to act.

The following note, " On the Course of the diurnal Fluctuations of the Barometer," by James P. Espy, A.M., of Philadelphia, was communicated by Dr. Apjohn.

" It is a law of inertia, that if a body is forced upwards, it will react and press on its support, more than its natural gravity; and if it is permitted to descend, it will press on its support less than its natural gravity, and the increase and diminution of pressure will be proportional to its velocity.

" Moreover, if a body is permitted to descend with a certain velocity, and then retarded, it will, when retarded, press more on its support than its natural gravity, and that in proportion to the rapidity of its retardation.

" This principle will explain the four fluctuations of the barometer which occur every day.

" Just before sunrise, when the atmosphere is neither becoming hotter nor colder, the barometer will indicate the natural weight of the air, which we may call a mean; as the sun rises the air will begin to expand by heat, and the whole atmosphere will be lifted up by this expansion, and by its reaction will cause the barometer to rise; and this will be the greatest, at the time when the air is receiving the most rapid accessions of heat, which must take place before the hottest time of the day, when the air is becoming neither hotter nor colder. On this principle, then, the maximum day fluctuation will take place between daylight in the morning and the hottest time of the day, and this corresponds with the fact; for this maximum, which amounts to more than the tenth of an inch, takes place about nine or ten o'clock, A. M.

" At the hottest part of the day, when the air is neither expanding nor contracting, it is manifest that the barometer will stand again at a mean. Soon after this, however, the air